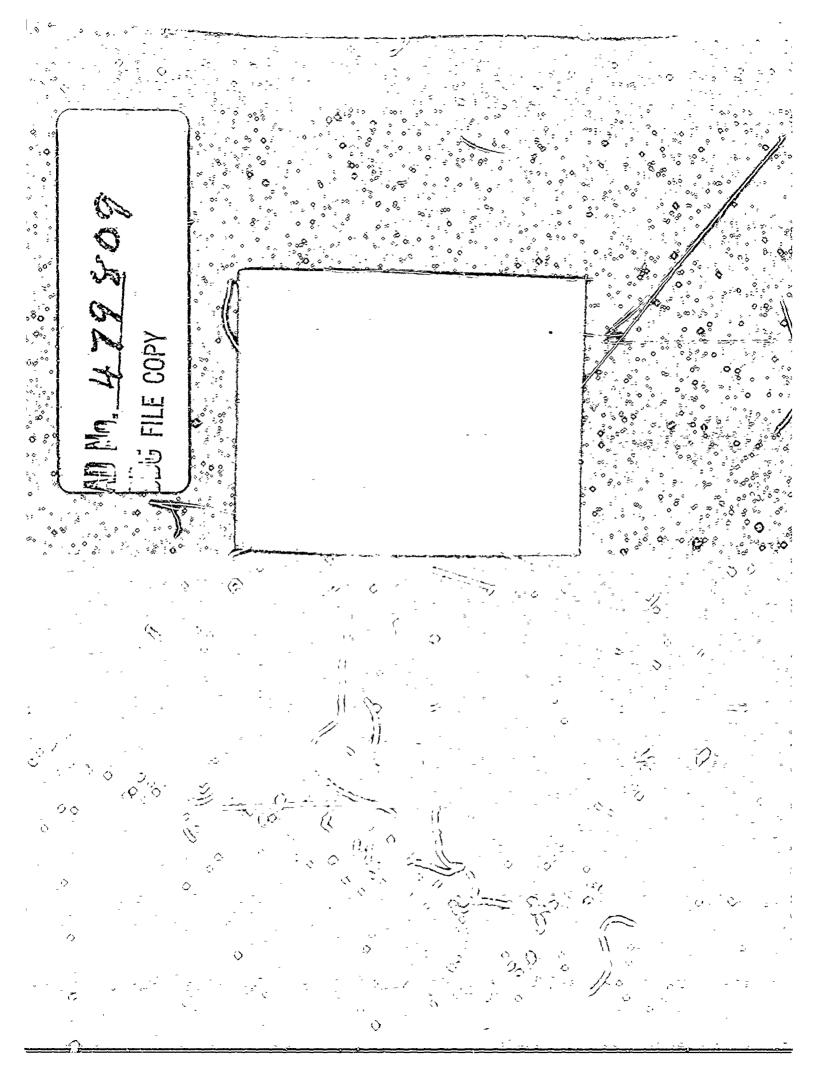
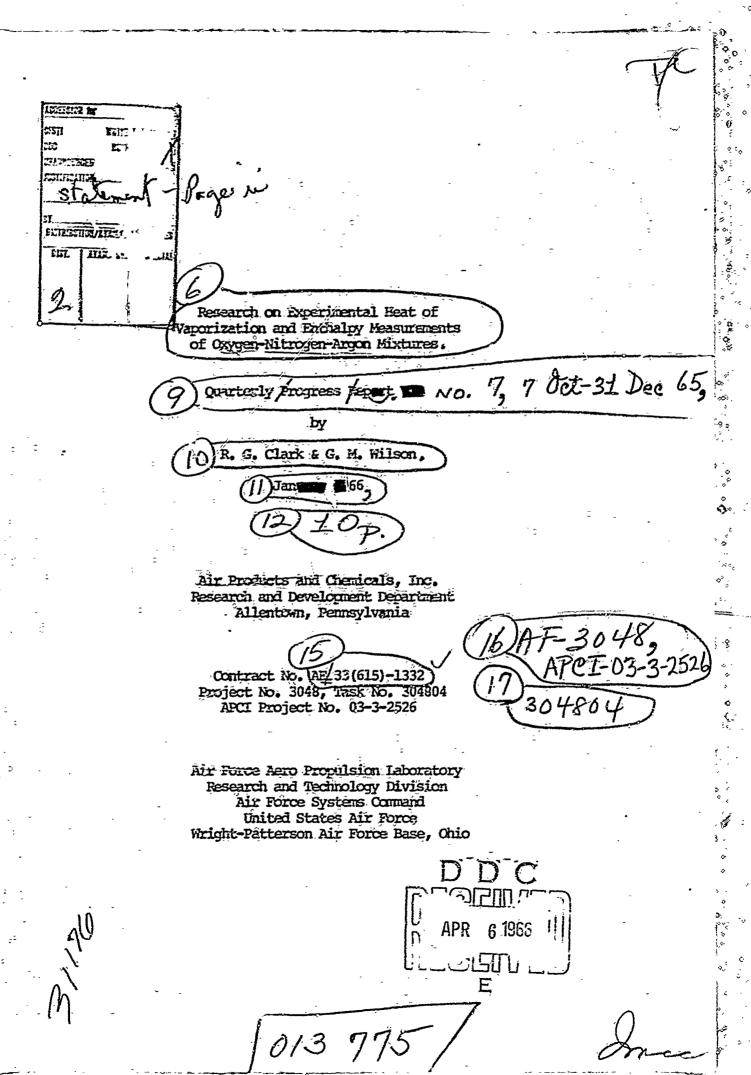
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FOREWORD

This report is the seventh of a series of written Quarterly Progress Reports which precede the Final Technical Documentary Report. This report summarizes the work done in connection with the experimental determination of enthalpy of caygen, nitrogen and argon mixtures from October 7, 1965 to December 31, 1965.

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ABSTRACT

This is the Seventh Quarterly Progress Report on the experimental determination of latent heats and enthalpy data of oxygen-nitrogen-argon three-component mixtures. Two hundred and one runs have been made during the past three-month period making a total of 2458 enthalpy points since the beginning of the project. This report summarizes the enthalpy data obtained during the past quarter.

TABLE OF CONTENTS.

	Pag	E
Ţ.	INTRODUCTION	
ų.	OPERATION AND MODIFICATIONS)
II.	EXPERIMENȚIAL DATA	Ì
IV.	SUMARY	j
V.	REFERENCES)

LIST OF TABLES

Table	,	Page
1	Gas Analyses	4
2	Experimental Enthalpy Data for 4% Ar in 10% N2/90% O2 Measured in Flow Calorimeter	5
3	Experimental Enthalpy Data for 5% Ar in 10% N2/90% O2 Measured in Plow Calorimeter	7

I. INTRODUCTION

This is the Seventh Quarterly Progress Report on the experimental determination of latent heats and enthalpy data of oxygen-nitrogen-argon three-component mixtures. Forty mixtures are being studied at pressure levels ranging from 0.1 to 25 atm over the range of compositions from 100% oxygen to 100% nitrogen and from 0.0% to 5.0% argon in the temperature range 100°R to 400°R. Details of the experimental equipment and the particular points to be measured are given in Quarterly Progress Report I(1). Modifications to the equipment are reported in Quarterly Progress Reports II(2), III(3), IV(4), V(5), and VI(6).

This report summarizes the enthalpy data obtained during the past quarter.

II. OPERATION AND MODIFICATIONS

buring this quarter continued experimental difficulties were experienced during enthalpy measurements on sub-cooled liquid samples in the flow calorimeter. While earlier modifications of the cold exit piping had improved system stability, further modifications performed during this quarter successfully solved the stability problem. Meaningful data are being obtained routinely at 125°R down to about 1 atmosphere pressure. The measurements program is again in full swing to complete the low temperature measurements in the flow calorimeter.

During a routine calibration of the wet test meters, a significant change in calibration was found for the process stream meter. The problem was identified as an cil leak in the meter. The problem was remedied and the affected enthalpy data points were rerun. Other than this, the calibration of the meters show random variations which are less than ±0.2%. This is consistant with the variations during previous quarters.

III. EXPERIMENTAL LATA

Two numbered and one enthalpy runs have been made in the flow calorimeter during the past quarter, making a total of 2458 runs since the beginning of the project. Due to malfunctioning of a wet test meter, one set of runs (sixty-six points) was repeated after meter repair. Therefore, one hundred and thirty-five valid data points were obtained. Two gas mixtures were studied. The nominal compositions are given in Table I along with the actual compositions as determined by gas chromatography.

The experimental enthalpy data are presented in Tables 1 and 2. In these tables ΔH is the measured enthalpy change and $H_{560}\text{-H}_{T}$ is the enthalpy normalized to a common inlet temperature of $560^{\circ}R$ as described in Quarterly Report II. Although figures of the plotted data are not presented, the agreement and consistency is as good as the data plotted in the previous Quarterly Reports.

rabie i cas analysis

Actual Composition	ise After Use Tables Containing	8 N2 8 AF 8 02	10.48 4.00 85.52	AR. AR 10. nn A. 9A BR. nr
Actual Composition	Before	& N2 & Ar & 02	9,7 4,05	1.17 A 38
Z.				
	Kominal Composition	% Ar	9.6 4.0 86.4	ů.
	(cmina	Ž	9,6	'n,

Table 2

EXPERIMENT EXHALPY DATA FOR

48 Ar in 108 N2/908 O2

MEASURED IN FLOX CALORITETER

Ram Ro. Art. PR PR Btt Btt		Pressure	Inlet	Outlet		-
2391	Rm lo.		Tep.	Tep.	(ii) Etu/lb-Vole	
2391	2390	25.01	562.3	400 o	1701	
15.01 562.9 400.0 1157 1135	2391	20.01	562.7	300 D		
10.02 553.3 400.1 1149 1126		15,01	562.9			
2394 7.01 563.6 399.9 1141 1116 2396 2.01 563.9 400.0 1133 1131 2397 1.00 565.2 399.8 1138 1162 2399 0.10 565.6 399.8 1135 1696 2400 25.00 565.2 499.0 1139 1100 2401 20.00 565.2 499.0 1139 1100 2401 20.00 562.2 350.2 1511 1565 2402 14.99 563.0 350.1 1563 1544 2403 10.00 563.4 350.2 1537 1515 2404 6.99 563.5 350.2 1596 1491 2406 19.99 563.5 350.2 1491 1467 2406 19.99 563.2 300.2 1962 1939 2408 9.99 563.7 300.1 1889 1893 2408 9.99 563.8 300.3 1923 1899 2408 9.99 563.8 300.3 1836 1829 2401 1.00 563.2 300.1 1845 1817 2410 1.00 563.2 300.1 1828 1797 2411 1.99 564.0 300.1 1828 1797 2411 1.99 564.3 300.1 1828 1797 2413 0.49 563.8 300.3 1815 1788 2416 9.98 561.6 250.0 2340 2328 2417 6.98 561.6 250.0 2340 2328 2418 4.98 562.1 200.0 2526 2557 2421 0.50 562.4 200.0 2526 2597 2422 0.10 563.2 200.0 2526 2597 2423 24.99 561.6 250.0 2526 2507 2421 0.50 562.4 200.0 2526 2597 2422 0.10 563.2 200.0 2526 2597 2421 0.50 562.4 200.0 2526 2597 2422 0.10 563.2 200.0 2526 2597 2423 24.99 561.1 200.0 2526 2597 2424 19.98 561.1 200.0 2539 2525 2427 6.99 561.1 200.0 2526 2597 2428 4.99 561.1 200.0 2530 2525 2429 1.99 562.7 200.0 2566 2597 2421 0.50 562.4 200.0 2516 2499 2422 0.10 563.2 200.0 2566 2583 2576 2423 1.99 561.1 206.6 2583 2576 2424 19.98 561.1 206.6 2583 2576 2425 14.99 561.5 200.5 5297 2587 2430 1.00 555.7 179.9 2697 2587 24330 25.00 560.8 150.1 5786 5780		10.02				
2395	_	7.01	563.6			
2396			563.9			
2397 1.00 555.2 399.8 1133 1162 2399 0.10 565.5 399.8 1133 1162 2399 0.10 565.5 400.0 1139 1102 2401 20.00 562.2 350.2 15kh 1565 2402 14.99 563.0 350.2 1537 1544 2403 10.00 563.4 350.2 1537 1515 2404 6.99 563.4 350.2 1597 1506 2409 19.99 563.5 350.2 1491 1467 2406 19.99 563.2 300.2 2008 1927 2407 14.99 563.0 300.2 2008 1927 2408 9.99 563.7 300.1 1889 1863 2409 6.99 563.8 300.3 1923 1899 2409 6.99 563.8 300.1 1885 1829 2409 6.99 564.0 300.1 1828 1797 2411 1.99 564.3 300.1 1828 1797 2412 1.00 563.2 300.2 1815 1788 2412 1.00 563.2 300.2 1815 1788 2414 0.10 564.2 300.2 1815 1788 2415 14.97 561.6 250.0 2340 2328 2417 6.98 561.7 250.2 2267 2328 2417 6.98 561.6 250.3 2231 227) 2419 1.98 562.1 200.0 2526 255 2410 1.99 562.4 200.0 2516 2499 2422 0.10 563.2 200.0 2516 2499 2422 0.10 563.2 200.0 2516 2499 2423 24,98 561.7 226.2 200.0 2516 2499 2426 9.99 561.1 239.1 2551 2559 2427 6.99 561.5 200.5 2587 2559 2428 4.99 561.1 239.1 2551 2559 2429 1.99 562.7 179.9 2697 2587 2430 1.00 558.4 174.6 2678 2689 2432 0.09 557.5 150.1 5667 5685 24330 25.00 550.8 150.1 5786 5780						
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2424 19.98 561.1 239.1 2551 2543 2425 14.99 559.6 228.7 2546 2549 2426 9.99 560.7 215.5 2569 2549 2427 6.99 561.1 206.5 2583 2576 2428 4.99 561.5 200.5 2597 2587 2429 1.99 562.7 179.9 2697 2678 2430 1.00 558.4 174.6 2678 2689 2431 0.50 559.0 166.4 2728 2689 2432 0.09 557.4 150.1 2857 2875 2433h 25.00 557.5 150.1 5667 5685 2433B 25.00 560.8 150.1 5786 5780			203.Z	• •		
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2426 9.99 560.7 215.5 2569 2549 2427 6.99 561.1 206.6 2583 2576 2428 4.99 561.5 200.5 2597 2587 2429 1.99 562.7 179.9 2697 2587 2430 1.00 558.4 174.6 2678 2689 2431 0.50 559.0 166.4 2728 2735 2432 0.09 557.4 150.1 2857 2875 2433A 25.00 557.5 150.1 5667 5685 2433B 25.00 560.8 150.1 5786 5780			26T*T			2543
2427 6.99 561.1 206.6 2583 2576 2428 4.99 561.5 200.5 2597 2587 2429 1.99 562.7 179.9 2697 2587 2430 1.00 558.4 174.6 2678 2689 2431 0.50 559.0 166.4 2728 2735 2432 0.09 557.4 150.1 2857 2875 2433h 25.00 557.5 150.1 5667 5685 2433B 25.00 560.8 150.1 5786 5780						
2428 4.99 561.5 200.5 2583 2576 2429 1.99 562.7 179.9 2697 2587 2430 1.00 558.4 174.6 2678 2689 2431 0.50 559.0 166.4 2728 2735 2432 0.09 557.4 150.1 2857 2875 2433h 25.00 557.5 150.1 5667 5685 2433B 25.00 560.8 150.1 5786 5780			564 7			2564
2429 1.99 562.7 179.9 2697 2678 2430 1.00 558.4 174.6 2678 2689 2431 0.50 559.0 166.4 2728 2735 2432 0.09 557.4 150.1 2857 2875 2433A 25.00 557.5 150.1 5667 5685 2433B 25.00 560.8 150.1 5786 5780	2428					2576
2430 1.00 558.4 174.6 2678 2689 2431 0.50 559.0 166.4 2728 2689 2432 0.09 557.4 150.1 2857 2875 2433A 25.00 557.5 150.1 5667 2875 2433B 25.00 560.8 150.1 5786 5780	2429					2587
2431 0.50 559.0 166.4 2728 2735 2432 0.09 557.4 150.1 2857 2875 2433h 25.00 557.5 150.1 5667 5685 2433B 25.00 560.8 150.1 5786 5780			558 A			
2432 0.09 557.4 150.1 2857 2875 2433h 25.00 557.5 150.1 5667 2875 2433B 25.00 560.8 150.1 5786 5780 2433C 25.00 560.9 150.2 5786 5780	2431					
2433h 25.00 557.5 150.1 2857 2875 2433B 25.00 560.8 150.1 5786 5780						2735
2433B 25.00 560.8 150.1 5786 5780						2875
2433C 25.00 560 9 150.1 5780 5780	2433B					5685
5787 5781	2433C					
			~0047	130,2	5787	5781

Szble 2 (continued)

		Inlet	Ontlet		
	Pressure	Temp.	Law.	(AE)	(H550-Hg)
Pun ?0.	Ain.	ح5	•हर्	Bby/li-Sole	Etu/lb-%ole
-	•				Dem an spies
24330	25.00	559.4	150.1	5637	5681
24343	20.00	559.2	150.0	5668	5674
24343	20.00	561.9	150.2	5869	5855
2435	14,99	555,8	150.Ĩ	5716	57 4 5
2435	9.99	554.1	150.1	5737	57 <u>7</u> 9
2437	6.99	554.0	150.0	5751	5794
2438	4.39	553.9	149.9	5816	5856
2439	4.00	554.7	190.3	5216	52 5 3
2440	7.01	<i>5</i> 55-0	200.0	5125	5153
2441	10.01	556.9	210.1	4944	4966
2442	35,00	557.2	223,5	4725	4745
2443	20.63	558.3	233.8	4542	4555
2444	25.01	559,2	242.1	4383	4389
2444	25.00	558.7	242.2	4396	4405
2445	25,60	559.0	199.8	50\$3	5106
2146	20.00	552, <i>G</i>	199,8	5978	5080
2447	25,00	560.1	244.4	3501	3501
2448A	€3. 9 \$	562.1	124.8	6221	6205
2449	19.99	561.5	124.8	6197	6186
2450	14.99	551.9	124.8	6298	6195
24485	25.01	557,6	124.9	6952	6070
2451	10,01	555,9	124.E	6196	6226
2452 2405a	7.01	554.0	124.7	6272	6315
2403A 2445A	24.99	553.7	302.0	1988	1991
2445B	24.99	555.2	203,5	4997	5031
2443D 2448C	24.99	554.6	204,8	5028	5067
2448D	25.01	555.8	125.3	6473	6496
2448E	24.99	555.7	129.4	6058	6089
2454	24.99	556.0	128.9	6088	6117
245 4 2455	1.99	557.6	130.1	6093	6110
2455 2456	0.99	558.7	129.9	6242	6251
2452A	0.49	557.9	129.7	6277	6292
24524 2453	7.01	548.9	126.0	6345	6423
2453 2454A	5.0%	550.5	125.8	6478	6545
2454A 2457	2.01	559.1	129.8	6248	6254
2457 2458	7.01	559.0	203.4	3816	3823
7430	15.01	559.5	226.5	3814	3818

Table 3

EXPERIMENTAL EXPERIMY DATA FOR

5% Ar in 10% 12/90% 02

MEASURED IN FLOW CALORIVETER

				-	
	~	Inict	Catlet		_
Dom No.	Pressure	gen.	Tep.	(公里)	(H ₅₅₀ -H ₁)
Per lo.	Atc.	<u>°P</u>	°R	Btu/ib-cole	Btu/Ib-cole
2324	25,60	564.1	399,5	1110	1031
2325	20.00	564.1	490.0	1072	1043
2325	14.99	564.3	339.8	1074	1044
2327	10.00	564.2	400.0	1059	1630
1328	7.08	564.4	490.0	1066	1035
2329	5.00	554.3	399.7	1041	1011
2330	2.00	564.9	399.8	1047	1014
2331	1.99	565.2	400.0	1061	1025
2332	0.50	564.5	399.9	1034	1003
2333	0.11	565,2	399.8	1034	993
2334	25.00	563.1	350.6	1501	1479
2335	20.00	563.3	350.2	1592	1478
2336	15.0 9	562.1	350.3	1498	1484
2337	10.00	562.0	350,1	1456	142
2338	7.00	562.1	350.2	1650	1482
2339	25.00	561.5	300.3	19%	1985
2340	20.00	561.7	300.4	1948	1936
2341	15.00	562.3	300.4	1566	1891
2342	10.01	562.3	300.4	1879	1863
2343	7.01	562.3	300.2	1860	1644
2314	5.01	562.9	300.0	1851	1831
2345	2.01	563.8	300.2	1838	1812
2345	1.00	564.7	300.2	1848	1816
2347	0.50	564.9	390.2	1840	1806
2348 2349	0.10	565.3	300.1	₁ 1838	1802
2350	15.00	563.1	249.9	<i>;</i> 2345	2323
2351	10.63	562 . 9	249.9	2270	2250
2352	7.01	560.9	250.2	2225	2219
2352	5.01	560.9	250.2	2200	2193
2354	2.01	562 . 7	200.1	2542	2523
2355 2355	1.00	563,7	199.9	2536	2511
2356 2356	0.50	564.0	199.8	2535	2508
2357	0.10	564.5	200.0	2528	2497
2358	25.01 20.01	563,2	247.3	2581	2558
2359	20.01	562.5	238.9	2558	254û
2360	15.00	562.4	228,7	2558	2541
2361	10.01	562.7	215.4	2576	2556
2362	7.03.	561.8	206.3	2585	2573
2363	5.01	562.1	200.4	2593	2579
2364	2.01	563 . 4	179.8	2701	2677
2365	1.00 0.50	564 . 2	175.3	2712	2682
2366	25 . 02	564.6	166.4	2779	2747
2367	20.02	561.6 561.1	124.8	6129	6117
eger i	20.02	COYOT	124.9	6110	6102

Table 3 (continued

Run Ho.	Pressure	Inlet Texp. °R	Outlet Texp. °R	(△II) Etu/lò-mle	(ii550-lir) Btu/lb-nole
2368 2369 2370 2371 2372 2373 2374 2375 2376 2377 2378 2379 2380 2381 2382 2383 2384 2385 2386 2387	15.02 10.03 7.02 5.02 0.10 25.02 20.01 25.01 20.01 15.02 7.02 5.02 7.02 19.02 19.02 19.02 15.01 20.01 25.01	560.7 559.6 559.7 559.9 567.2 562.6 558.6 560.0 558.9 557.7 558.9 559.9 560.2 561.1 561.5 562.1 563.0 561.2	124.8 125.0 124.7 124.7 146 200.1 150.0 150.0 150.1 150.1 150.1 150.1 150.1 120.3 199.3 210.1 223.6 233.9 242.1 244.0	6167 6111 5139 6201 3015 5059 5037 5657 5672 5700 5718 5725 5823 5235 5823 5235 5084 4921 4743 4531 4385 3772	6162 6113 6202 6202 2965 5040 5047 5674 5672 5708 5734 5739 5835 5236 5083 4914 4733 4516 4364
2388 2389	15.01 7.01	560 . 3 560 . 8	225.5 202.0	3649 3782	3763 3647 3777

IV. SUPPARY

During the past quarter, 201 enthalpy runs have been made making a total of 2458 prints measured since the beginning of the project.

Considerable experimental difficulties were encountered and overcome during this quarter, a fact which explains the relatively small number of valid data points obtained. An oil leak in a wet test meter necessitated the repeat of one set of runs (66 points). Exploratory tests have lead to modifications of the cold exit piping which permit valid measurements to be made in the sub-cooled liquid region. The apparatus operates stablely at 125°R down to 1 atmosphere. The measurements program is again in full swing to complete the low temperature tests in the flow calorimeter.

V. REFERENCES

- W. H. Lien and G. N. Wilson, "Research on Experimental Heat of Vaporization and Enthalpy Measurements of Oxygen-Nitrogen-Argon Mixtures", Quarterly Progress Report I, Contract No. AF 33(615)-1332, July 1964.
- W. H. Lien and G. H. Wilson, "Research on Experimental Heat of Vaporization and Enthalpy Measurements of Oxygen-Nitrogen-Argon Mixtures", Quarterly Progress Report II, Contract No. AF 33(615)-1332, October 1964.
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- 6. G. M. Wilson, "Research on Experimental Heat of Vaporization and Enthalpy Measurements of Oxygen-Nitrogen-Argon Mixtures", Quarterly Progress Report VI, Contract No. AF 33(615)-1332, October 1965.